

FINAL REPORT

EXECUTIVE SUMMARY

I-40 East Corridor Profile Study

I-17 to Arizona/New Mexico State Line

PREPARED FOR **ADOT** MARCH 2017

ADOT WORK TASK NO.
MPD 043-15

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11-013164

Prepared by

AECOM



EXECUTIVE SUMMARY

INTRODUCTION

The Arizona Department of Transportation (ADOT) is the lead agency for this Corridor Profile Study (CPS) of Interstate 40 (I-40) between Interstate 17 (I-17) and the New Mexico State Border. This study examines key performance measures relative to the I-40 East Corridor, and the results of this performance evaluation are used to identify potential strategic improvements. The intent of the corridor profile program, and of ADOT’s Planning-to-Programming (P2P) process, is to conduct performance-based planning to identify areas of need and make the most efficient use of available funding to provide an efficient transportation network.

ADOT is conducting eleven CPS within three separate groupings. The I-40 East Corridor, depicted in **Figure ES-1**, is one of the strategic statewide corridors identified and the subject of this CPS.

Corridor Study Purpose, Goals and Objectives

The purpose of the CPS is to measure corridor performance to inform the development of strategic solutions that are cost-effective and account for potential risks. This purpose can be accomplished by following the process described below:

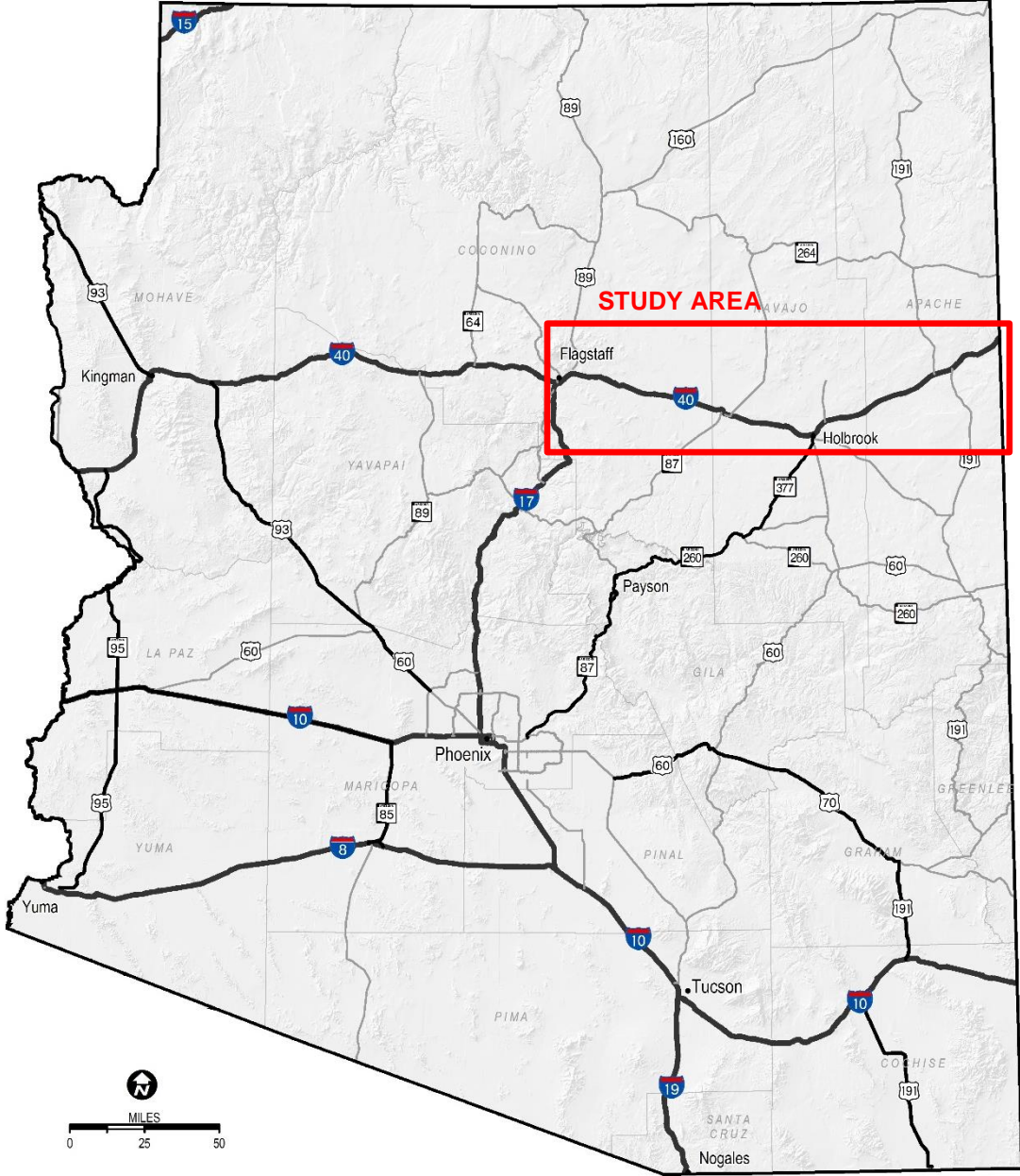
- Inventory past improvement recommendations
- Define corridor goals and objectives
- Assess existing performance based on quantifiable performance measures
- Propose various solutions to improve corridor performance
- Identify specific solutions that can provide quantifiable benefits relative to the performance measures
- Prioritize solutions for future implementation, accounting for performance effectiveness and risk analysis findings

The objective of this study is to identify a recommended set of prioritized potential solutions for consideration in future construction programs, derived from a transparent, defensible, logical, and replicable process. The I-40 East CPS defines solutions and improvements for the corridor that are evaluated and ranked to determine which investments offer the greatest benefit to the corridor in terms of enhancing performance.

The following goals are identified as the outcome of this study:

- Link project decision-making and investments on key corridors to strategic goals
- Develop solutions that address identified corridor needs based on measured performance
- Prioritize improvements that cost-effectively preserve, modernize, and expand transportation infrastructure

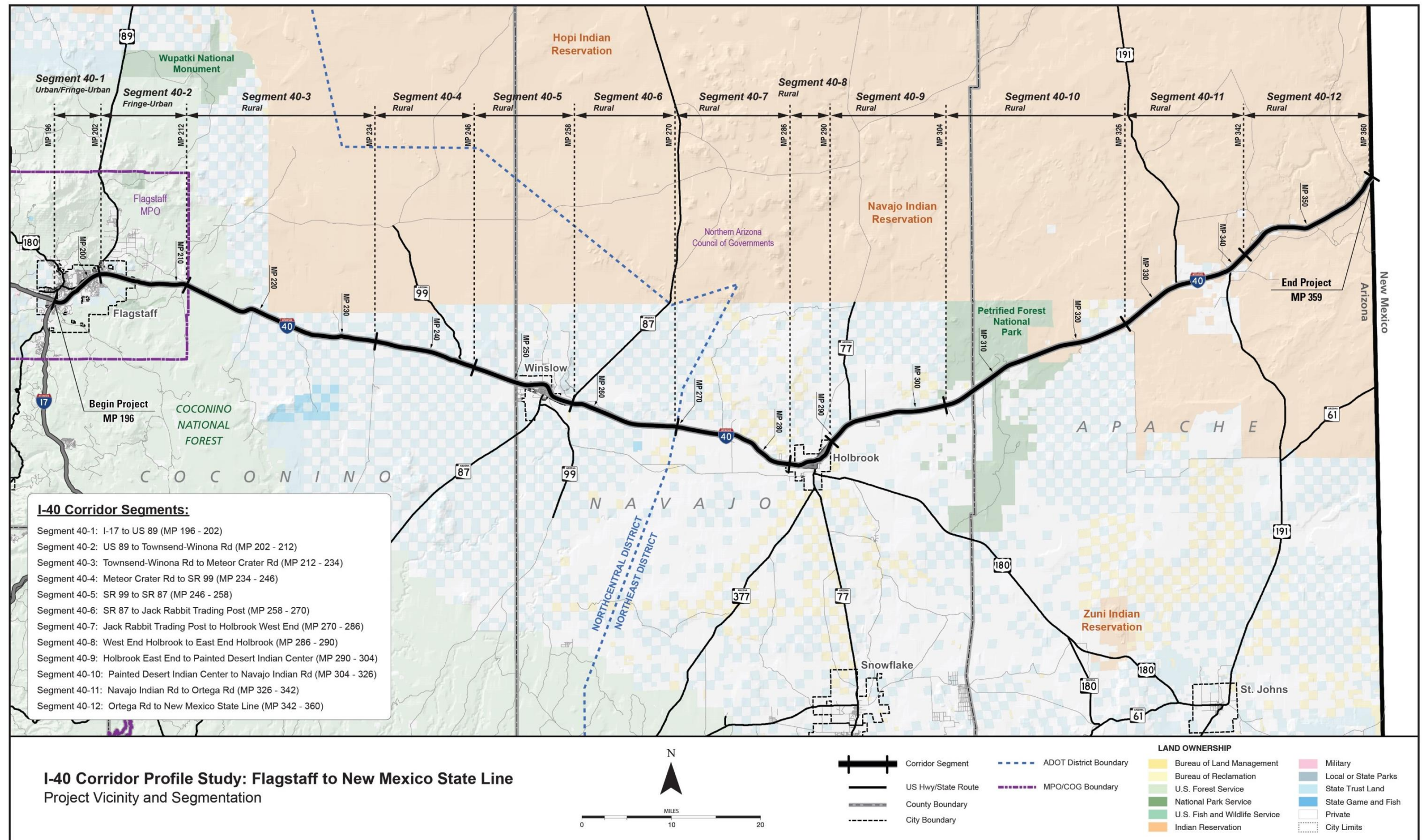
Figure ES-1: Corridor Study Area



Study Location and Corridor Segments

The I-40 East Corridor is divided into 12 planning segments for analysis and evaluation. The corridor is segmented at logical breaks where the context changes due to differences in characteristics such as terrain, daily traffic volumes, or roadway typical sections. Corridor segments are shown in **Figure ES-2**.

Figure ES-2: Corridor Location and Segments



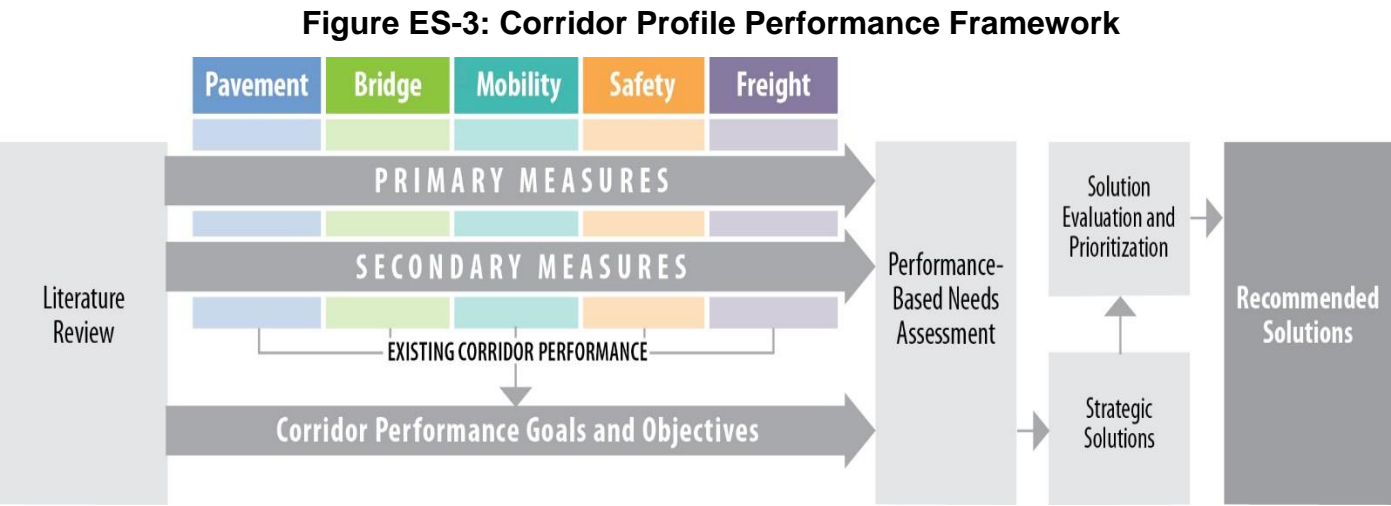
CORRIDOR PERFORMANCE

A series of performance measures is used to assess the I-40 East Corridor. The results of the performance evaluation are used to define corridor needs relative to the long-term goals and objectives for the corridor.

Corridor Performance Framework

This study uses a performance-based process to define baseline corridor performance, diagnose corridor needs, develop corridor solutions, and prioritize strategic corridor investments. In support of this objective, a framework for the performance-based process was developed through a collaborative process involving ADOT and the CPS consultant teams.

Figure ES-3 illustrates the performance framework, which includes a two-tiered system of performance measures (primary and secondary) to evaluate baseline performance.



The following five performance areas guide the performance-based corridor analyses:

- Pavement
- Bridge
- Mobility
- Safety
- Freight

The performance measures include five primary measures: Pavement Index, Bridge Index, Mobility Index, Safety Index, and Freight Index. Additionally, a set of secondary performance measures provides for a more detailed analysis of corridor performance. **Table ES-1** provides the complete list of primary and secondary performance measures for each of the five performance areas.

Table ES-1: Corridor Performance Measures

Performance Area	Primary Measure	Secondary Measures
Pavement	Pavement Index Based on a combination of International Roughness Index and cracking	<ul style="list-style-type: none"> • Directional Pavement Serviceability • Pavement Failure • Pavement Hot Spots
Bridge	Bridge Index Based on lowest of deck, substructure, superstructure and structural evaluation rating	<ul style="list-style-type: none"> • Bridge Sufficiency • Functionally Obsolete Bridges • Bridge Rating • Bridge Hot Spots
Mobility	Mobility Index Based on combination of existing and future daily volume-to-capacity ratios	<ul style="list-style-type: none"> • Future Congestion • Peak Congestion • Travel Time Reliability • Multimodal Opportunities
Safety	Safety Index Based on frequency of fatal and incapacitating injury crashes	<ul style="list-style-type: none"> • Directional Safety Index • Strategic Highway Safety Plan Emphasis Areas • Crash Unit Types • Safety Hot Spots
Freight	Freight Index Based on bi-directional truck planning time index	<ul style="list-style-type: none"> • Recurring Delay • Non-Recurring Delay • Closure Duration • Bridge Vertical Clearance • Bridge Vertical Clearance Hot Spots

Each of the primary and secondary performance measures identified in the table above is comprised of one or more quantifiable indicators. A three-level scale was developed to standardize the performance scale across the five performance areas, with numerical thresholds specific to each performance measure:

Good/Above Average Performance	– Rating is above identified desirable/average range
Fair/Average Performance	– Rating is within identified desirable/average range
Poor/Below Average Performance	– Rating is below identified desirable/average range

The terms “good”, “fair”, and “poor” apply to the Pavement, Bridge, Mobility, and Freight performance measures, which have defined thresholds. The terms “above average”, “average”, and “below average” apply to the Safety performance measures, which have thresholds referenced to statewide averages.

Corridor Performance Summary

Table ES-2 shows a summary of corridor performance for all primary measures and secondary measure indicators for the I-40 East Corridor. A weighted corridor average rating (based on the length of the segment) was calculated for each primary measure as shown in **Table ES-2**.

100% of the corridor show “good” performance in both the Pavement Index and Mobility Index. Approximately 93% of the corridor show “good” performance in Freight, while the remaining 7% show “poor” performance. The Bridge Index displays 82% of the corridor in “fair” condition, and 18% in “good” condition. In the Safety Index, approximately 23% of the corridor shows “below average” performance, while the other 21% and 56% are shown as “average” and “above average” performance, respectively.

Based on the results of the corridor performance evaluation, the following general observations could be made related to the performance of the I-40 East Corridor:

- The pavement generally has “good” performance with the exception of a few isolated locations
- The bridges generally have “fair” performance overall, however 32 of the 112 bridges on the corridor have a rating of 4 or multiple 5’s
- 50% of the segments have at least one bridge with a rating of 4
- The general mobility and freight indices along the corridor are displaying “good” performance where both are also showing very little recurring and non-recurring delays
- The closures along the corridor generally exceed or equal the statewide average for both the closure frequency and duration
- A majority of the segments have either “above average” or “average” performance for the Safety Index, however the western end of the corridor has “below average” performance
- There are very few crash hot spots throughout the corridor

Table ES-2: Corridor Performance Summary by Segment and Performance Measure

Segment	Segment Length (miles)	Pavement Performance Area				Bridge Performance Area				Mobility Performance Area												
		Pavement Index	Directional PSR		% Area Failure	Bridge Index	Sufficiency Rating	% of Deck Area on Functionally Obsolete Bridges	Lowest Bridge Rating	Mobility Index	Future Daily V/C	Existing Peak Hour V/C		Closure Extent (instances/ milepost/year/mile)		Directional TTI (all vehicles)		Directional PTI (all vehicles)		% Bicycle Accommodation	% Non-Single Occupancy Vehicle (SOV) Trips	
			EB	WB								EB	WB	EB	WB	EB	WB	EB	WB			
40-1 ^{a1}	6	4.17	3.90	4.01	0.0%	6.19	92.87	7.9%	5	0.71	0.90	0.40	0.39	0.63	0.17	1.01	1.03	1.13	1.15	100%	17.6%	
40-2 ^{b1}	10	3.83	3.47	3.85	25.0%	5.83	96.90	18.3%	5	0.42	0.58	0.20	0.16	0.54	0.20	1.00	1.00	1.21	1.31	100%	15.4%	
40-3 ^{b2}	22	4.22	4.12	4.04	5.0%	5.03	88.55	0.0%	4	0.49	0.69	0.22	0.20	0.51	0.11	1.00	1.00	1.23	1.29	100%	7.6%	
40-4 ^{b2}	12	4.40	4.20	4.30	0.0%	6.05	95.94	0.0%	5	0.49	0.69	0.19	0.19	0.50	0.17	1.00	1.00	2.24	1.23	100%	11.2%	
40-5 ^{a2}	12	4.05	3.90	3.93	0.0%	5.12	90.45	0.0%	4	0.52	0.73	0.21	0.20	0.30	0.18	1.06	1.04	1.45	1.44	100%	12.5%	
40-6 ^{b2}	12	4.10	3.92	4.00	0.0%	5.15	86.18	29.1%	5	0.38	0.53	0.18	0.17	0.11	0.00	1.00	1.00	1.20	1.20	100%	14.2%	
40-7 ^{b2}	16	3.96	3.89	3.86	3.0%	5.31	85.29	0.0%	4	0.51	0.71	0.21	0.20	0.03	0.05	1.00	1.00	1.24	1.24	100%	17.5%	
40-8 ^{b2}	4	4.41	4.13	4.20	0.0%	5.43	84.09	14.8%	4	0.40	0.54	0.21	0.21	0.05	0.05	1.00	1.00	1.29	1.36	100%	21.3%	
40-9 ^{b2}	14	4.16	3.99	4.04	4.0%	7.19	96.17	22.4%	6	0.48	0.65	0.28	0.28	0.10	0.21	1.00	1.00	1.41	1.36	98%	14.5%	
40-10 ^{b2}	22	4.41	4.18	4.31	0.0%	5.45	82.78	42.2%	4	0.46	0.63	0.23	0.24	0.15	0.07	1.00	1.00	1.27	1.22	100%	10.5%	
40-11 ^{b2}	16	4.31	4.23	4.18	0.0%	6.81	95.43	59.3%	5	0.44	0.60	0.20	0.19	0.12	0.07	1.00	1.01	1.29	1.37	96%	9.9%	
40-12 ^{b2}	18	4.08	4.08	4.21	6.0%	5.94	92.69	57.5%	4	0.47	0.64	0.24	0.24	0.11	0.11	1.00	1.00	1.24	1.31	90%	12.0%	
Weighted Corridor Average		4.18	4.03	4.09	3.5%	5.76	90.30	23.6%	4.51	0.48	0.65	0.23	0.22	0.25	0.11	1.00	1.01	1.34	1.29	98%	12.53%	
SCALES																						
Performance Level		Interstate				All				Urban or Rural				All		Uninterrupted				All		
Good/Above Average		> 3.75	> 3.75		< 5%	> 6.5	> 80	< 12%	> 6	< 0.71 (Urban) < 0.56 (Rural)				< 0.22		< 1.15		<1.30		> 90%		> 17%
Fair/Average		3.2 - 3.75	3.2 - 3.75		5% - 20%	5.0 - 6.5	50 - 80	12% - 40%	5 – 6	0.71 - 0.89 (Urban) 0.56 - 0.76 (Rural)				0.22 – 0.62		1.15-1.33		1.30-1.50		60% - 90%		11% - 17%
Poor/Below Average		< 3.2	< 3.2		> 20%	< 5.0	< 50	> 40 %	< 5	> 0.89 (Urban) > 0.76 (Rural)				> 0.62		> 1.33		>1.50		< 60%		< 11%

^a Urban 4 Lane Freeway
^b Rural 4 Lane Freeway < 25,000 vpd

¹Urban or Fringe Urban Operating Environment
²Rural Operating Environment

Table ES-2: Corridor Performance Summary by Segment and Performance Measure, (continued)

Segment	Segment Length (miles)	Safety Performance Area				Freight Performance Area							
		Safety Index	Directional Safety Index		% of Fatal + Incapacitating Injury Crashes Involving SHSP Top 5 Emphasis Areas Behaviors	Freight Index	Directional TTTI		Directional TPTI		Closure Duration (mins/milepost/year/mile)		Bridge Vertical Clearance (feet)
			EB	WB			EB	WB	EB	WB	EB	WB	
40-1 ^{a1}	6	1.77	1.56	1.97	69%	0.86	1.05	1.06	1.16	1.17	240.70	21.10	16.23
40-2 ^{b1}	10	1.89	2.41	1.36	76%	0.88	1.02	1.06	1.10	1.16	211.46	76.44	16.03
40-3 ^{b2}	22	1.35	1.46	1.23	68%	0.88	1.03	1.05	1.12	1.15	219.43	26.30	16.52
40-4 ^{b2}	12	0.07	0.04	0.11	Insufficient Data	0.65	1.07	1.05	1.90	1.16	191.15	43.57	16.85
40-5 ^{a2}	12	0.42	0.10	0.75	83%	0.79	1.11	1.09	1.29	1.26	107.58	41.57	16.32
40-6 ^{b2}	12	1.14	1.16	1.13	55%	0.89	1.03	1.04	1.11	1.13	23.77	0.00	No UP
40-7 ^{b2}	16	0.24	0.40	0.08	80%	0.88	1.05	1.03	1.15	1.13	3.09	15.64	16.09
40-8 ^{b2}	4	0.94	0.11	1.78	Insufficient Data	0.85	1.05	1.04	1.17	1.20	4.75	3.60	16.87
40-9 ^{b2}	14	0.32	0.50	0.14	56%	0.79	1.06	1.05	1.28	1.23	27.63	81.13	16.16
40-10 ^{b2}	22	0.66	0.93	0.39	47%	0.88	1.04	1.04	1.15	1.12	42.22	26.00	16.02
40-11 ^{b2}	16	0.64	0.49	0.80	75%	0.85	1.04	1.05	1.18	1.19	25.81	16.89	16.00
40-12 ^{b2}	18	1.24	1.77	0.71	27%	0.88	1.03	1.04	1.13	1.16	25.54	36.65	16.06
Weighted Corridor Averages		0.84	0.95	0.74	61.6%	0.84	1.05	1.05	1.22	1.17	88.49	32.89	16.24
SCALES													
Performance Level		Urban 4-Lane Freeway or Rural 4-Lane Freeway < 25,000 vpd				Uninterrupted				All			
Good/Above Average		a b	< 0.79 < 0.73		< 49.1% < 42.8%	> 0.77	< 1.15		< 1.30		< 44.18		> 16.5
Fair/Average		a b	0.79 – 1.21 0.73 – 1.27		49.1% - 59.4% 42.8% - 52.9%	0.67 - 0.77	1.15 -1.33		1.30 -1.50		44.18 -124.86		16.0-16.5
Poor/Below Average		a b	> 1.21 > 1.27		> 59.4% > 52.9%	< 0.67	> 1.33		>1.50		> 124.86		< 16.0

^a Urban 4 Lane Freeway

¹Urban or Fringe Urban Operating Environment

^b Rural 4 Lane Freeway < 25,000 vpd

²Rural Operating Environment

Notes: "Insufficient Data" indicates there was not enough data available to generate reliable performance ratings

"No UP" indicates no underpasses are present in the segment

NEEDS ASSESSMENT

Corridor Description

The I-40 East Corridor is part of I-40, a major east-west transcontinental interstate highway that connects the east coast (North Carolina) to the west coast (California). I-40 East is a major transportation artery route for freight as well as passenger vehicular traffic, connecting major metropolitan cities in the south-western United States. I-40 East is also the primary transportation route connecting the Phoenix metropolitan area to central and north-eastern parts of the country. I-40 East, together with I-17, plays a key role in the transportation infrastructure of northern Arizona, contributing to its economic success.

Corridor Objectives

Statewide goals and performance measures were established by the ADOT Long-Range Transportation Plan (LRTP), 2010-2035. Statewide performance goals that are relevant to I-40 East performance areas were identified and corridor goals were then formulated for each of the five performance areas that aligned with the overall statewide goals established by the LRTP. Based on stakeholder input, corridor goals, corridor objectives, and performance results, three “emphasis areas” were identified for the I-40 East Corridor: Pavement, Bridge, and Safety.

Taking into account the corridor goals and identified emphasis areas, performance objectives were developed for each quantifiable performance measure that identify the desired level of performance based on the performance scale levels for the overall corridor and for each segment of the corridor. For the performance emphasis areas, the corridor-wide weighted average performance objectives are identified with a higher standard than for the other performance areas.

Achieving corridor and segment performance objectives will help ensure that investments are targeted toward improvements that support the safe and efficient movement of travelers on the corridor. Corridor performance is measured against corridor and segment objectives to determine needs – the gap between observed performance and performance objectives.

Needs Assessment Process

The performance-based needs assessment evaluates the difference between the baseline performance and the performance objectives for each of the five performance areas used to characterize the health of the corridor: Pavement, Bridge, Mobility, Safety, and Freight. The performance-based needs assessment process is illustrated in **Figure ES-4**.

The needs assessment compares baseline corridor performance with performance objectives to provide a starting point for the identification of performance needs. This mathematical comparison results in an initial need rating of None, Low, Medium, or High for each primary and secondary performance measure. An illustrative example of this process is shown in **Figure ES-5**.

The initial level of need for each segment is refined to account for hot spots and recently completed or under construction projects, resulting in a final level of need for each segment. The final levels of need for each primary and secondary performance measure are combined to produce a weighted

final need rating for each segment. A detailed review of available data helps identify contributing factors to the need and if there is a high level of historical investment.

Figure ES-4: Needs Assessment Process

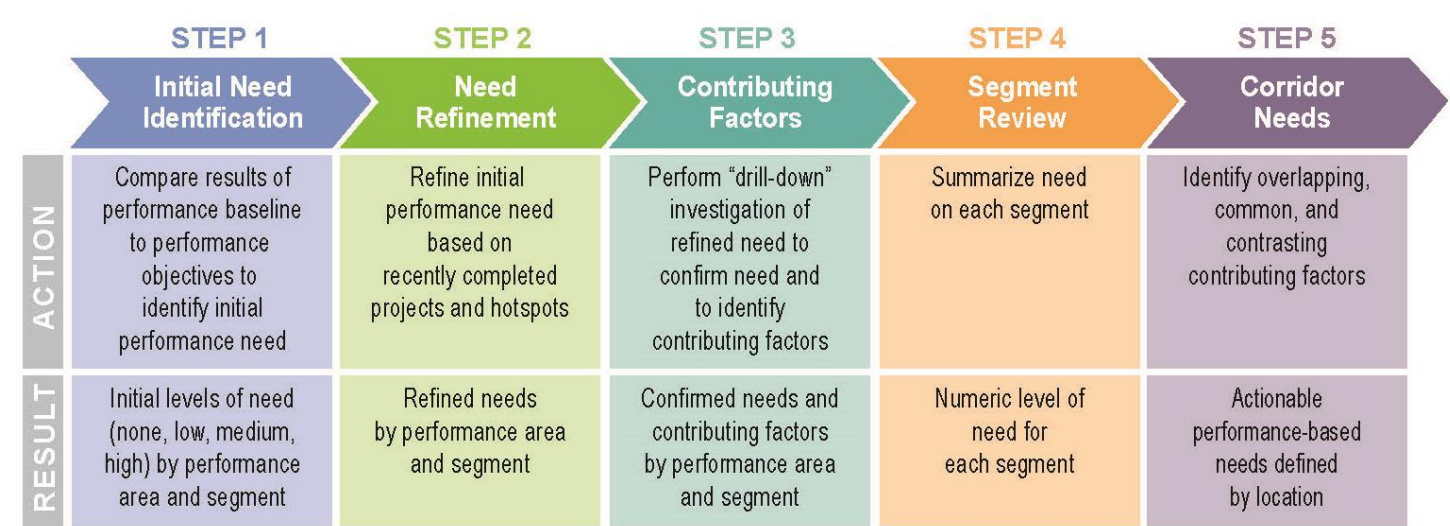


Figure ES-5: Initial Need Ratings in Relation to Baseline Performance (Bridge Example)

Performance Thresholds	Performance Level	Initial Level of Need	Description
6.5	Good	None*	All levels of Good and top 1/3 of Fair (>6.0)
	Good		
	Good		
5.0	Fair	Low	Middle 1/3 of Fair (5.5-6.0)
	Fair		
	Fair	Medium	Lower 1/3 of Fair and top 1/3 of Poor (4.5-5.5)
	Poor		
	Poor	High	Lower 2/3 of Poor (<4.5)
	Poor		

**A segment need rating of ‘None’ does not indicate a lack of needed improvements; rather, it indicates that the segment performance score exceeds the established performance thresholds and strategic solutions for that segment will not be developed as part of this study.*

Summary of Needs

Table ES-3 provides a summary of needs for each segment across all performance areas, with the average need score for each segment presented in the last row of the table. A weighting factor of 1.5 is applied to the need scores of the performance areas identified as emphasis areas (Pavement, Bridge, and Safety) for the I-40 East Corridor. There are no segments with a High average need, six segments with a Medium average need, and six segments with a Low average need. More information on the identified final needs in each performance area is provided below.

Pavement Needs

- Pavement failure hot spots were identified on 4 miles of eastbound I-40 East and 1 mile of westbound I-40 East spread throughout the corridor.
- The eastbound direction of I-40 East appears to have a higher level of performance need which may warrant consideration of alternative treatments on the eastbound roadway.
- A high level of historical investment has occurred on approximately 108 miles (66% of centerline miles) of the corridor (MP 196-212, MP 246-304 and MP 326-360) which may warrant further investigation or alternative solutions.

Bridge Needs

- Bridge needs were identified at 46 of the 112 bridges (38%).
- 16 bridges have current ratings of one 5.
- 14 bridges have current ratings of multiple 5's.
- 6 bridges have current ratings of 4 or less.
- 30 bridges have current deck ratings of 5 or less.
- 23 bridges have potential historical rating issues which may be candidates for life-cycle cost analysis to evaluate alternative solutions.

Mobility Needs

- Future (2035) travel demand is anticipated to exceed capacity on approximately 4% of corridor, generally in Flagstaff near the I-17 System Interchange.
- A higher than average number of closures due to accidents, incidents, obstructions, or hazards occur from MP 196 to 258 primarily due to weather.
- The lowest trip reliability on corridor is along eastbound I-40 between MP 234 and 246. This segment coincides with closures that may also be due to weather.

Safety Needs

- Safety needs were identified on 150 miles (92%) of the corridor.
- The highest levels of need have been identified from MP 196 to 234 and from MP 258 to 270.
- Approximately 70% of the crashes along the corridor were Single Vehicle crashes, and 52% involved an overturning vehicle with 43% involves a first unit event of ran off the road (left).
- Approximately 21% of the crashes involved under the influence of drugs or alcohol.
- MP 196-202 and MP 246-258 crashes involved a higher percentage of pedestrian and pedalcyclist crashes than similar operating environments.
- Crash hot spots near MP 198 to 199 westbound and 210 to 212 eastbound may be weather and/or lighting related

Freight Needs

- The highest level of need was identified from MP 234 to 246, this segment was identified to have closure and PTI issues which maybe weather related. ADOT Districts confirmed that this segment of roadway have been closed multiple times due to wind.
- A higher than average number of closures due to accidents, incidents, obstructions, or hazards occurs from MP 196 to 258 primarily due to weather.

Overlapping Needs

Strategic solutions that address more than one performance area with elevated levels of Need may present the opportunity to more effectively improve overall performance. On the I-40 East Corridor, overlapping needs in the Bridge and Safety performance areas occur on three segments. However, there does not appear to be a correlation between the contributing factors for these needs.

Table ES-3: Summary of Needs by Segment

Performance Area	Segment Number and Mileposts (MP)											
	40-1	40-2	40-3	40-4	40-5	40-6	40-7	40-8	40-9	40-10	40-11	40-12
	MP 196-202	MP 202-212	MP 212-234	MP 234-246	MP 246-258	MP 258-270	MP 270-286	MP 286-290	MP 290-304	MP 304-326	MP 326-342	MP 342-359
Pavement ⁺	None	Low	None	None	None	None	Low	None	Low	None	None	Low
Bridge ⁺	Low	Low	Medium	Low	Low	Medium	Medium	Low	Low	Low	Low	Medium
Mobility	Low	Low	Low	Low	Low	None	Low	None	Low	Low	None	Low
Safety ⁺	High	High	High	None	Low	High	Low	Low	Low	Low	Low	Medium
Freight	Low	Low	Low	High	Low	None	Low	None	Low	Low	Low	Low
Average Need	1.23	1.46	1.46	0.85	0.77	1.15	1.23	0.46	1.00	0.77	0.62	1.46

**A segment need rating of ‘None’ does not indicate a lack of needed improvements; rather, it indicates that the segment performance score exceeds the established performance thresholds and strategic solutions for that segment will not be developed as part of this study.*

+ Identified as an emphasis area for I-40 East Corridor

Average Need Scale	
None*	< 0.1
Low	0.1 - 1.0
Medium	1.0 - 2.0
High	> 2.0

STRATEGIC SOLUTIONS

The principal objective of the CPS is to identify strategic solutions (investments) that are performance-based to ensure that available funding resources are used to maximize the performance of the State’s key transportation corridors. One of the first steps in the development of strategic solutions is to identify areas of elevated levels of need as addressing these needs will have the greatest effect on corridor performance. Segments with Medium or High needs and specific locations of hot spots are considered strategic investment areas for which strategic solutions should be developed. Segments with lower levels of need or without identified hot spots are not considered candidates for strategic investment and are expected to be addressed through other ADOT programming processes. The I-40 East strategic investment areas (resulting from the elevated needs) are shown in **Figure ES-6**.

Screening Process

In some cases, needs that are identified do not advance to solutions development and are screened out from further consideration because they have been or will be addressed through other measures including:

- A project is programmed to address this need
- The need is a result of a Pavement or Bridge hot spot that does not show historical investment issues. These hot spots will likely be addressed through other ADOT programming means
- A bridge is not a hot spot but is located within a segment with a Medium or High level of need. This bridge will likely be addressed through current ADOT bridge maintenance and preservation programming processes
- The need is determined to be non-actionable (i.e., cannot be addressed through an ADOT project)
- The conditions/characteristics of the location have changed since the performance data was collected that was used to identify the need

Candidate Solutions

For each elevated need within a strategic investment area that is not screened out, a candidate solution is developed to address the identified need. Each candidate solution is assigned to one of the following three P2P investment categories based on the scope of the solution:

- Preservation
- Modernization
- Expansion

Documented performance needs serve as the foundation for developing candidate solutions for corridor preservation, modernization, and expansion. Candidate solutions are not intended to be a substitute or replacement for traditional ADOT project development processes where various ADOT technical groups and districts develop candidate projects for consideration in the performance-based

programming in the P2P process. Rather, these candidate solutions are intended to complement ADOT’s traditional project development processes through a performance-based process to address needs in one or more of the five performance areas of Pavement, Bridge, Mobility, Safety, and Freight. Candidate solutions developed for the I-40 East Corridor will be considered along with other candidate projects in the ADOT statewide programming process.

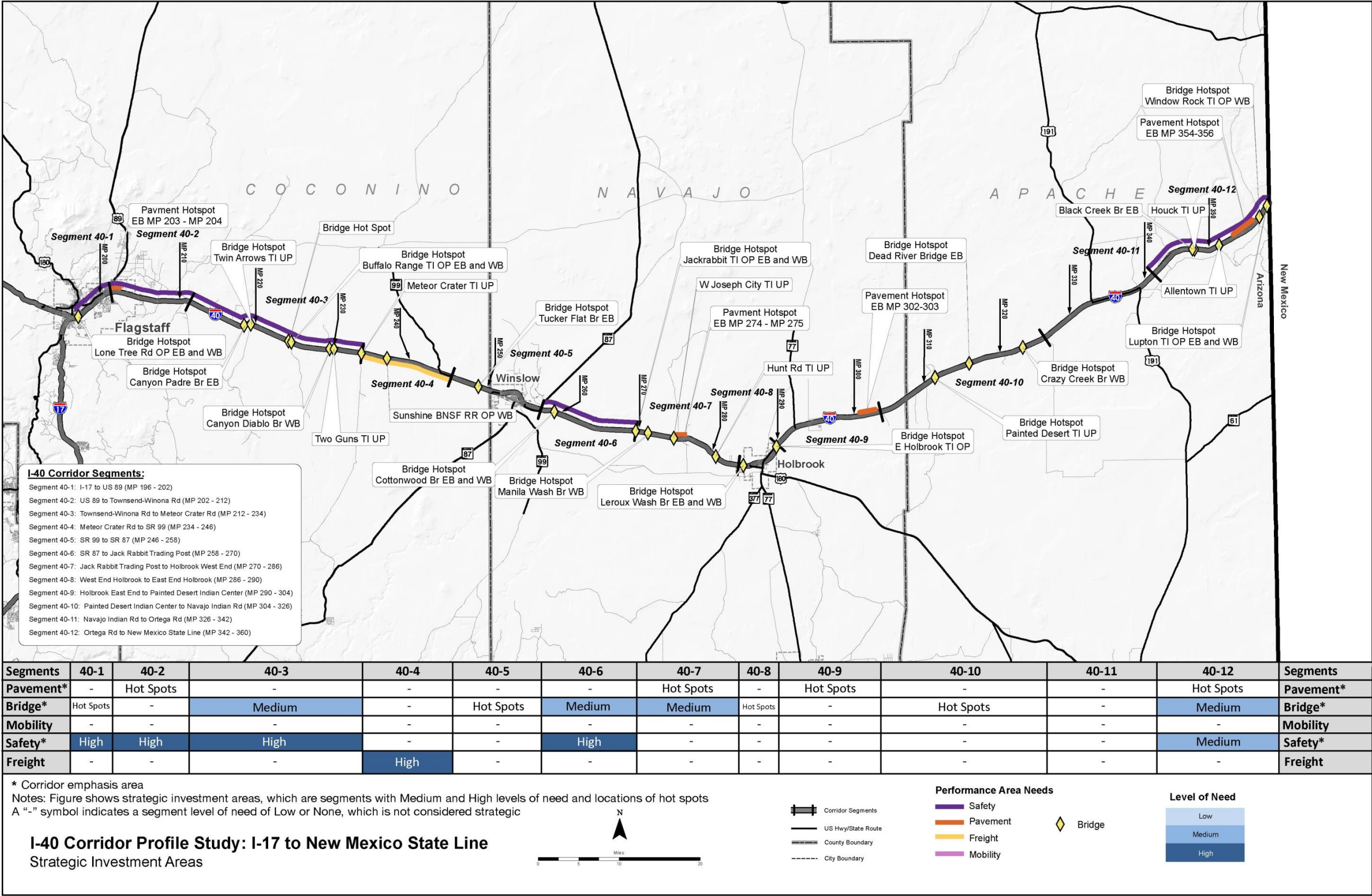
Candidate solutions should include some or all of the following characteristics:

- Do not recreate or replace results from normal programming processes
- May include programs or initiatives, areas for further study, and infrastructure projects
- Address elevated levels of need (High or Medium) and hot spots
- Focus on investments in modernization projects (to optimize current infrastructure)
- Address overlapping needs
- Reduce costly repetitive maintenance
- Extend operational life of system and delay expansion
- Leverage programmed projects that can be expanded to address other strategic elements
- Provide measurable benefit

Candidate solutions developed to address an elevated need in the Pavement or Bridge performance areas include two options: rehabilitation or full replacement. These solutions are initially evaluated through a Life-Cycle Cost Analysis (LCCA) to provide insights into the cost-effectiveness of these options so a recommended approach can be identified. Candidate solutions developed to address an elevated need in the Mobility, Safety, or Freight performance areas are advanced directly to the Performance Effectiveness Evaluation. In some cases, there may be multiple solutions identified to address the same area of need.

Candidate solutions that are recommended to expand or modify the scope of an already programmed project are noted and are not advanced to solution evaluation and prioritization. These solutions are directly recommended for programming.

Figure ES-6: Strategic Investment Areas



SOLUTION EVALUATION AND PRIORITIZATION

Candidate solutions are evaluated using the following steps: LCCA (where applicable), Performance Effectiveness Evaluation, Solution Risk Analysis, and Candidate Solution Prioritization. The methodology and approach to this evaluation is shown in **Figure ES-7** and described more fully below.

Life-Cycle Cost Analysis

All Pavement and Bridge candidate solutions have two options: rehabilitation/repair or reconstruction. These options are evaluated through an LCCA to determine the best approach for each location where a Pavement or Bridge solution is recommended. The LCCA can eliminate options from further consideration and identify which options should be carried forward for further evaluation.

All Mobility, Safety, and Freight strategic investment areas that result in multiple independent candidate solutions are advanced directly to the Performance Effectiveness Evaluation.

Performance Effectiveness Evaluation

After completing the LCCA process, all remaining candidate solutions are evaluated based on their performance effectiveness. This process includes determining a Performance Effectiveness Score (PES) based on how much each solution impacts the existing performance and needs scores for each segment. This evaluation also includes a Performance Area Risk Analysis to help differentiate between similar solutions based on factors that are not directly addressed in the performance system.

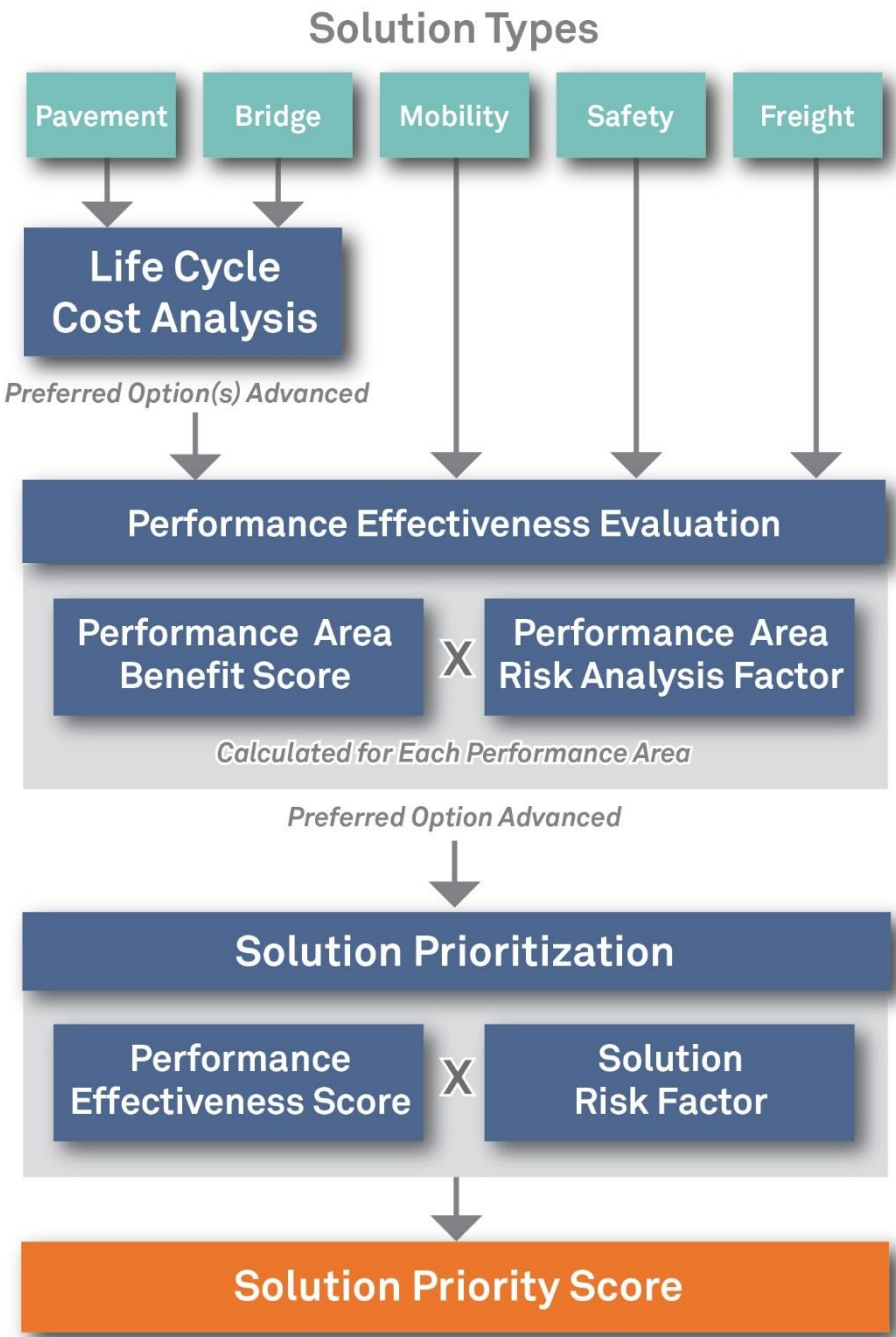
Solution Risk Analysis

All candidate solutions advanced through the Performance Effectiveness Evaluation are also evaluated through a Solution Risk Analysis process. A solution risk probability and consequence analysis is conducted to develop a solution-level risk weighting factor. This risk analysis is a numeric scoring system to help address the risk of not implementing a solution based on the likelihood and severity of the performance failure.

Candidate Solution Prioritization

The PES, weighted risk factor, and segment average need score are combined to create a prioritization score. The candidate solutions are ranked by prioritization score from highest to lowest. The highest prioritization score indicates the candidate solution that is recommended as the highest priority. Solutions that address multiple performance areas tend to score higher in this process.

Figure ES-7: Candidate Solution Evaluation Process



SUMMARY OF CORRIDOR RECOMMENDATIONS

Prioritized Candidate Solution Recommendations

Table ES-4 and **Figure ES-8** show the prioritized candidate solutions recommended for the I-40 East Corridor. These solutions will increase the performance of the I-40 East Corridor across a majority of the performance areas. Solutions that address multiple performance areas tend to score higher in this process.

- Four solutions result in a Prioritization Score above 80 which shows that their performance benefits are much higher than their cost.
- Two of the top five solutions include the installation of lighting in locations where 60% - 70% of the fatal and serious injury crashes occur in dark conditions.
- All five of the highest ranking solutions are located where the Safety Index was the highest along the corridor.
- Two safety hotspots were identified along the corridor and those corresponding solutions are ranked in the top eight.

Other Corridor Recommendations

As part of the investigation of strategic investment areas and candidate solutions, other corridor recommendations can also be identified. These recommendations could include modifications to the existing Statewide Construction Program, areas for further study, or other corridor-specific recommendations that are not related to construction or policy. The list below identifies other corridor recommendations for the I-40 East Corridor:

- The analysis shows a high number of fatal and incapacitating injury crashes that are attributed to behavior conditions in the first three segments of the corridor. This report recommends that a Roadway Safety Analysis should be conducted on this portion of the corridor in order to better understand the high occurrence of behavior crashes and possibly designate this portion of the corridor as a “Safety Corridor”.
- Input from the North Central District and North Eastern District indicated subgrade issues in the pavement from approximately Mileposts 196 to 202 which was confirmed with a high historical investment. However, the most current data included in pavement records indicate no current need was present at the time the data was collected. This report recommends that the materials section study this section of pavement further prior to the next rehabilitation project to confirm if this section of roadway needs reconstruction.
- When recommending future projects along the I-40 East Corridor, review historical ratings and levels of investment. According to data used for this study, the following pavement and bridge locations have exhibited high historical investment (pavement) or rating fluctuation (bridge) issues:
 - Pavement MP 196-203
 - Pavement MP 204-212
 - Pavement MP 246-275

- Pavement MP 276-304
- Pavement MP 326-360
- Canyon Padre Br EB (MP 218.73)
- Twin Arrows TI UP (MP 219.53)
- Canyon Diablo Br WB (MP 229.90)
- Sunshine BNSF RR OP WB (MP 237.10)
- Little Colo River Br EB/WB (MP 256.95)
- W Joseph City TI UP (#1893) (MP 274.76)
- Hunt Rd TI UP (MP 280.64)
- Navajo TI UP (MP 325.92)
- McCarroll TI UP (MP 330.00)
- Chambers TI UP (MP 333.41)
- Ortega Rd TI UP (MP 341.81)
- Black Creek Br EB (MP 347.90)

Policy and Initiatives Recommendations

In addition to location-specific needs, general corridor and system-wide needs have also been identified through the CPS process. While these needs are more overarching and cannot be individually evaluated through the CPS process, it is important to document them. A list of recommended policies and initiatives was developed for consideration when programming future projects not only on the I-40 East Corridor, but across the entire state highway system where conditions are applicable. The following list, which is in no particular order of priority, was derived from the Round 1, Round 2, and Round 3 CPS:

- Install Intelligent Transportation System (ITS) conduit with all new infrastructure projects
- Prepare strategic plans for Closed Circuit Television (CCTV) camera and Road Weather Information System (RWIS) locations statewide
- Leverage power and communication at existing weigh-in-motion (WIM), dynamic messaging signs (DMS), and call box locations to expand ITS applications across the state
- Consider solar power for lighting and ITS where applicable
- Investigate ice formation prediction technology where applicable
- Conduct highway safety manual evaluation for all future programmed projects
- Develop infrastructure maintenance and preservation plans (including schedule and funding) for all pavement and bridge infrastructure replacement or expansion projects
- Develop standardized bridge maintenance procedures so districts can do routine maintenance work
- Review historical ratings and level of previous investment during scoping of pavement and bridge projects; in pavement locations that warrant further investigation, conduct subsurface investigations during project scoping to determine if full replacement is warranted
- For pavement rehabilitation projects, enhance the amount/level of geotechnical investigations to address issues specific to the varying conditions along the project

- Expand programmed and future pavement projects as necessary to include shoulders
- Expand median cable barrier guidelines to account for safety performance
- Install CCTV cameras with all DMS
- In locations with limited communications, use CCTV cameras to provide still images rather than streaming video
- Develop statewide program for pavement replacement
- Install additional continuous permanent count stations along strategic corridors to enhance traffic count data
- When reconstruction or rehabilitation activities will affect existing bridge vertical clearance, the dimension of the new bridge vertical clearance should be a minimum of 16.25 feet where feasible
- All new or reconstructed roadway/shoulder edges adjacent to an unpaved surface should be constructed with a Safety Edge
- Collision data on tribal lands may be incomplete or inconsistent; additional coordination for data on tribal lands is recommended to ensure adequate reflection of safety issues
- Expand data collection devices statewide to measure freight delay
- Evaluate and accommodate potential changes in freight and goods movement trends that may result from improvements and expansions to the state roadway network

Next Steps

Candidate solutions developed for the I-40 East will be considered along with other candidate projects in the ADOT statewide programming process. It is important to note that the candidate solutions are intended to represent strategic solutions to address existing performance needs related to the Pavement, Bridge, Mobility, Safety, and Freight performance areas. Therefore, the strategic solutions are not intended to preclude recommendations related to the ultimate vision for the corridor that may have been defined in the context of prior planning studies and/or design concept reports. Recommendations from such studies are still relevant to addressing the ultimate corridor objectives.

Upon completion of all three CPS rounds, the results will be incorporated into a summary document comparing all corridors that is expected to provide a performance-based review of statewide needs and candidate solutions.

Table ES-4: Prioritized Recommended Solutions

Rank	Candidate Solution #	Solution Name and Location	Description / Scope	Estimated Cost (in millions)	Investment Category (Preservation [P] Modernization [M] Expansion [E])	Prioritization Score
1	CS40.05	Flagstaff Pedestrian Improvements (MP 198-200)	Install access barrier fence (8-ft fencing) along the residential section of the roadway between mileposts (MP's) 198 and 200. The project includes construction of a grade separated pedestrian crossing, including ramps and sidewalks leading to the structure.	\$2.82	M	115
2	CS40.08	Walnut Canyon & Cosnino TI Lighting (MP 204.5 - 207.5)	Install offset solar powered LED lighting at Walnut Canyon TI (MP 205) and Cosnino TI (MP 207). Includes light poles, luminaires, and solar panels.	\$0.99	M	97
3	CS40.03	Flagstaff Safety Improvements (MP 196 – 200)	Rehabilitate shoulder and widen the inside shoulder. Implement variable speed limits using a wireless ground mount construction. Install in-lane route pavement markings for the westbound I-40/I-17 interchange. Install a Roadside Weather Information System (RWIS), a closed circuit television (CCTV) camera near the existing DMS at MP 199.6 Eastbound, and rock-fall mitigation (wire mesh) near MP 199.	\$9.39	M	91
4	CS40.06	Butler TI (MP 198.5 - 199.5)	Construct or extend parallel entrance and exit ramps at Butler TI at MP 199. Includes pavement, striping, signing, RPMs, lighting, minor earthwork, and drainage.	\$4.43	M	81
5	CS40.04	Flagstaff Lighting (MP 196 – 202)	Install offset lighting along I-40 between MP's 196 and 202 by connecting to existing power. This includes light poles, luminaires, pull boxes, conduit, and conductors.	\$8.06	M	79
6	CS40.07	East Flagstaff Safety Improvements (MP 200 – 207)	Improve skid resistance from MP 200 to 202 by reconstructing pavement, increasing super-elevation, or mill and replace. Install chevrons and curve warning signs from MP 200 to 202. Rehabilitate shoulder and widen the inside shoulder. Implement variable speed limits using a wireless ground-mount construction.	\$18.04	M	62
7	CS40.09	Winona Safety Improvements (MP 207 – 212)	Improve skid resistance from MP 207 to 208 and from MP 210 to 212 by reconstructing pavement, increasing super-elevation, or mill and replace. Install chevrons and curve warning signs from MP 207 to 208 and from MP 210 to 212. Rehabilitate shoulder and widen the inside shoulder. Implement variable speed limits using a wireless ground-mount construction. Install RWIS and a new eastbound Dynamic Message Sign (DMS) near MP 212.1 with attached CCTV nearby.	\$17.44	M	59
8	CS40.25	Lupton East Safety Improvements (MP 351 – 359)	Rehabilitate shoulder	\$3.38	M	55
9	CS40.24	Lupton West Safety Improvements (MP 345 -351)	Improve skid resistance from MP 345 to 346, MP 346.5 to 347, and MP 349.5 to 350.5 by reconstructing pavement, increasing super-elevation, or mill and replace. Install striping, pavement markers, delineators, rumble strips, chevrons and curve warning signs from MP 345 to 346, MP 346.5 to 347, and MP 349.5 to 350.5. Install dynamic speed feedback systems near MP 345 eastbound and MP 351 westbound. Install a dynamic wind warning system near MP 349-350 and RWIS near MP 349-350.	\$10.17	M	31
10	CS40.10	Country Club & Walnut Canyon (MP 201.5 – 205.5)	Construct or extend parallel entrance and exit ramps at Country Club TI (MP 202) and Walnut Canyon TI (MP 205). Includes pavement, striping, signing, RPMs, lighting, minor earthwork, and drainage.	\$8.85	M	31

Table ES-4: Prioritized Recommended Solutions (continued)

Rank	Candidate Solution #	Solution Name and Location	Description / Scope	Estimated Cost (in millions)	Investment Category (Preservation [P] Modernization [M] Expansion [E])	Prioritization Score
11	CS40.17	East Winslow Safety Improvements (MP 258 – 266)	Improve skid resistance from MP 258 to 260 by reconstructing pavement, increasing super-elevation, or mill and replace. Install dynamic speed feedback systems near MP 258 eastbound and MP 260 westbound. Install a CCTV camera near the existing DMS located at MP 260.2 WB. Rehabilitate shoulder	\$10.30	M	26
12	CS40.13	Canyon Diablo Safety Improvements (MP 220 – 229)	Rehabilitate shoulder and widen the inside shoulder. Install RWIS and dynamic wind warning system near MP 222-223.	\$9.61	M	21
13	CS40.14	Twin Arrows TI (MP 219.5 – 220.5)	Construct or extend parallel entrance and exit ramps at Twin Arrows TI (MP 220). Includes pavement, striping, signing, RPMs, lighting, minor earthwork, and drainage.	\$4.43	M	11
14	CS40.12	Canyon Diablo West Safety Improvements (MP 218 – 220)	For the entire length of the project (MP 218 – 220) improve skid resistance by reconstructing pavement, increasing super-elevation, or mill and replace. Install chevrons and curve warning signs. Install a dynamic speed feedback system near MP 218 eastbound and MP 220 westbound.	\$7.07	M	11
15	CS40.26	Lupton Area TI Improvements (MP 347.5 – 360)	Construct or extend parallel entrance and exit ramps at Houck TI (MP 348), Lupton TI (MP 359), and Westbound Rest Area (MP 359). Includes pavement, striping, signing, RPMs, lighting, minor earthwork, and drainage.	\$11.06	M	7
16	CS40.15	Canyon Diablo East Safety Improvements (MP 229 – 230)	For the entire length of the project (MP 229 – 230) improve skid resistance by reconstructing pavement, increasing super-elevation, or mill and replace. Install chevrons and curve warning signs. Install a dynamic speed feedback system near MP 229 eastbound and MP 230 westbound. Retrofit RWIS at the Two Guns TI at MP 230.	\$3.70	M	5
17	CS40.11	West of Walnut Canyon Pavement (MP 202-205 EB)	Replace pavement in the eastbound direction between MP 203 and 204.	\$12.92	M	5

Figure ES-8: Prioritized Recommended Solutions

